The astronaut is stationary relative to himself, so the time he measures for his own blood circulation is $\Delta t_s = 45 \text{ s}$. To an Earth-based observer, the corresponding time interval is $\Delta t_M$, with $\gamma = 2$; so from Eq. (26.2)

$$\Delta t_M = \gamma \Delta t_s = 2(45 \text{ s}) = 90 \text{ s}.$$

### 26.7

In this case the life time of the particle measured in the lab frame is $\Delta t_M = 20 \text{ ns}$, and $\Delta t_s$, the life time measured when the particle is stationary, satisfies $\Delta t_M = \gamma \Delta t_s$; so

$$\Delta t_s = \frac{\Delta t_M}{\gamma} = \frac{20 \text{ ns}}{10} = 2.0 \text{ ns}.$$

### 26.10

The one-hour time interval the astronaut sets for her nap is measured onboard the spaceship, in which the event (the nap) is stationary. So $\Delta t_s = 1.00 \text{ h}$. For an observer on Earth who is moving relative to the spaceship at $\nu = 0.600c$, the nap should last $\Delta t_M$, with

$$\Delta t_M = \frac{\Delta t_s}{\sqrt{1 - \nu^2/c^2}} = \frac{1.00 \text{ h}}{\sqrt{1 - (0.600c/c)^2}} = 1.25 \text{ h},$$

which is how long the flight controller on Earth should let her sleep as measured on his clock.

### 26.12

The time dilation factor is $\Delta t_M/\Delta t_s = \gamma = 1/\sqrt{1 - \beta^2}$, where $\beta = \nu/c$, with $\nu = 1800 \text{ mi/h}$. Convert the unit of $\nu$ into $\text{m/s}$: $\nu = (1800 \text{ mi/h})(1609 \text{ m/mi})(1.000 \text{ h/3600 s}) = 804.67 \text{ m/s}$. Thus $\beta = \nu/c = (804.67 \text{ m/s})/(2.998 \times 10^8 \text{ m/s}) = 2.684 \times 10^{-6} \ll 1$, so from the binomial approximation $(1 + x)^n \approx 1 + nx$ for $|x| \ll 1$, we have, with $n = -\frac{1}{2}$ and $x = -\beta^2$,

$$\gamma = (1 - \beta^2)^{-\frac{1}{2}} \approx 1 + \left(-\frac{1}{2}\right)(-\beta^2) = 1 + \frac{1}{2}(2.684 \times 10^{-6})^2 = 1.00000000036,$$

which equals 1.000 to four significant figures — which is as many as we can keep. If the approximation is not used, then

$$\gamma = \frac{1}{\sqrt{1 - \beta^2}} = \frac{1}{\sqrt{1 - (2.684 \times 10^{-6})^2}}.$$

### 26.14

The life time of the particle, measured in its rest frame, is $\Delta t_s = 20 \text{ ns}$. When it travels at $\nu = 0.80c$ with respect to the laboratory its life time measured in the laboratory frame is now dilated to $\Delta t_M = \Delta t_s/\sqrt{1 - \nu^2/c^2}$. If the particle moves at a uniform speed of $\nu = 0.8c$ during its entire life time, it covers a distance of

$$L = \nu \Delta t_M = \frac{\nu \Delta t_s}{\sqrt{1 - (\nu/c)^2}} = \frac{(0.8 \times 2.998 \times 10^8 \text{ m/s})(20 \times 10^{-9} \text{ s})}{\sqrt{1 - (0.8c/c)^2}} = 8 \text{ m}.$$